FACT SHEET - ATTACHMENT A

MIRANT KENDALL STATION NPDES PERMIT

Permit No. MA0004898

REQUIREMENTS TO ADDRESS WATER QUALITY IMPACTS IN THE CHARLES RIVER DUE TO EXCESSIVE ALGAE GROWTH

Eutrophication and Related Aquatic Life/Aesthetic Impairments

This portion of the fact sheet is focused on eutrophication of the Charles River Basin and describes the basis for including eutrophication related monitoring requirements in the permit and EPA's proposal not to authorize operation of the diffuser proposed by the permittee at this time. See Section 5 of the Determination Document for the discussion on potential impacts of thermal loads on fish populations. The monitoring requirements are intended to provide the Agencies (EPA and MADEP) with critical information for assessing whether the operation of the Kendall Square Station (the facility) is causing or contributing to eutrophication and associated water quality impairments in the vicinity of the facility discharge in the lower Charles River Basin.

The Charles River Basin has been assessed by the MADEP to be in non-attainment with Massachusetts Water Quality Standards due to a number of stressors related to excessive algal growth or cultural eutrophication. EPA is concerned that the increased thermal load associated with the upgraded facility may increase the severity of summer-time algal blooms in the Basin and possibly result in the proliferation of undesirable species such as blue green algae. However, EPA is uncertain at this time as to whether the facility's thermal load associated with complying with the summer in-stream temperature limit (i.e., 83 ºF) included in the draft permit to protect the fish populations of the Basin represents a reasonable potential to cause or contribute to the non-attainment with Massachusetts Water Quality Standards. Therefore, eutrophication-related monitoring requirements rather than compliance monitoring requirements are proposed for the draft permit. With respect to the proposed diffuser, EPA believes that a reasonable potential exists that the operation of the proposed diffuser will worsen summer-time algal blooms in the lower Basin.

This portion of the fact sheet provides discussions of the following topics:

> (1) Water quality of the lower Charles River Basin including monitoring and applicable Massachusetts Water Quality Standards and eutrophication-related water quality impairments (see pages 2-12);
>
> (2) Development of the permit to address eutrophication of the lower Charles River Basin including EPA's proposal not to permit the diffuser outfall at this time (see pages 12-28);

(3) Total Maximum Daily Load (TMDL) study that will determine pollutant loading reductions that are necessary to correct all water quality impairments related to eutrophication in the Charles River Basin (see pages 32-33).

Water Quality of the Charles River Basin

<u>Background.</u> The Charles River Basin (Basin), defined as the river segment between the Watertown Dam and the New Charles River Dam, is a highly valued recreational resource. The Basin provides an ideal setting for a variety of recreational activities in and along the Basin, including rowing, sailing, concerts, running, and numerous sporting activities on the adjacent parklands. Due to longstanding and pervasive water quality problems in the Basin, contact recreational activities such as kayaking, sail-boarding, and swimming have been limited because of high bacteria levels, poor aesthetic quality, and contaminated sediments. During the past several years, however, intensive efforts to reduce the discharge of untreated sanitary wastes to the Basin from combined sewer overflows (CSOs) and illicit sanitary sewage discharges have increased the frequency in which Massachusetts' bacterial Water Quality Standards are attained for contact recreational sports. However, designated recreational and aquatic life uses are still not fully supported within the Basin despite these efforts. Some of the remaining water quality problems in the Basin include the regular occurrence of severe algal blooms during the summer months, high bacteria levels following rainfall, reduced water clarity, contaminated sediments, and anoxic bottom waters that do not support aquatic life.

In 1995, EPA New England established the Clean Charles 2005 Initiative. The goal of the Initiative is to improve water quality in the Charles River Basin and fully restore recreational (e.g., swimmable) and aquatic life (e.g., fishable) uses (EPA, 1999). The ongoing Initiative incorporates a comprehensive approach for improving water quality through CSO controls, illicit sanitary source removals, storm water management, advanced treatment for nutrients at upstream waste water treatment facilities, public outreach, monitoring, enforcement, and technical assistance. The Initiative has provided funding for numerous studies of the Basin including comprehensive assessments of water quality, contaminated sediments, salt water intrusion, pollutant loadings to the Basin, and watershed modeling. Additionally, Total Maximum Daily Load (TMDL) studies involving the development of predictive water quality models are presently underway to address excessive pollutant loadings that cause use impairments in the Charles River Basin. As explained more completely on pages 32-33 of this fact sheet, a TMDL is a quantification of the pollutant loads a body of water can receive while still meeting applicable water quality standards.

<u>Applicable Massachusetts Water Quality Standards</u>. The Massachusetts Water Quality Standards (MAWQS) identify the Charles River Basin as a Class B water that is designated to support aquatic life and recreational uses. Permit conditions for any facility cannot allow a source to cause or contribute to the non-attainment of the water quality standards. A summary of the MAWQS that are relevant to this permit and the Basin are presented below, including those criteria that are in non-attainment because of excessive algal biomass.

314 CMR: 4.03: Application of Standards (1) Establishment of Effluent Limitations. The Division will limit or prohibit discharges of pollutants to surface waters to assure that surface water quality standards of the receiving waters are protected and maintained or attained. The level of treatment for an individual discharger will be established by the discharge permit in accordance with 314 CMR 3.00. In establishing water quality based effluent limitations the Division shall take into consideration background conditions and existing discharges. Discharges shall be limited or prohibited to protect existing uses and not interfere with the attainment of designated uses in downstream adjacent segments. The Division shall provide a reasonable margin of safety to account for any lack of knowledge concerning the relationship between the pollutants being discharged and their impact on water quality.

314 CMR: 4.05: Classes and Criteria (3)(b) Class B. These waters are designated as a habitat for fish, other aquatic life, and wildlife, and for primary and secondary contact recreation. These waters shall have consistently good aesthetic value.

314 CMR: 4.05: Classes and Criteria (3)(b) 1. Dissolved Oxygen. Shall not be less than 5.0 mg/l in warm water fisheries unless background conditions are lower; natural seasonal and daily variations above these levels shall be maintained; and levels shall not be lowered below 60 percent of saturation in warm water fisheries due to a discharge.

314 CMR: 4.05: Classes and Criteria (3)(b) 2. Temperature.(a) Shall not exceed 83 ºF (28.3 ºC) in warm water fisheries, and the rise in temperature due to a discharge shall not exceed 5 ºF (2.8 ºC) in rivers and streams designated as warm water fisheries (based on the minimum expected flow for the month); in lakes and ponds the rise shall not exceed 3ºF (1.7 ºC) in the epilimnion (based on the monthly average of maximum daily temperature); and (b) natural seasonal and daily variations shall be maintained. There shall be no changes from background conditions that would impair any use assigned to this Class, including site-specific limits necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms.

314 CMR: 4.05: Classes and Criteria (3)(b) 3. pH. Shall be in the range of 6.5 - 8.3 standard units and not more than 0.5 units outside of the background range. There shall be no change from background conditions that would impair any use assigned to this class.

314 CMR: 4.05: Classes and Criteria (3)(b) 5. Solids. These waters shall be free from floating, suspended, and settleable solids in concentrations and combinations that would impair any use assigned to this Class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.

314 CMR: 4.05: Classes and Criteria (3)(b) 6. Color and Turbidity. These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically

objectionable or would impair any use assigned to this Class.

314 CMR: 4.05: Classes and Criteria (5)(a) Aesthetics - All Surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life.

314 CMR: 4.05: Classes and Criteria (5)(c) Nutrients - Shall not exceed the site specific limits necessary to control accelerated or cultural eutrophication.

Water Quality of the Charles River Basin. In 1998, EPA New England's Regional Laboratory began a Core Monitoring Program to document water quality conditions and track water quality improvements in the Charles River Basin as pollution controls are implemented. EPA's Core Monitoring Program is conducted annually during July, August, and September when peak recreational uses occur in the Basin, and includes both dry (three per year) and wet (typically two) weather surveys. EPA's monitoring is conducted in accordance with an approved Quality Assurance Project Plan (QAPP) and includes dry weather sampling at twelve stations, ten of which are located within the Basin, and wet weather sampling at a minimum of six stations. Samples are analyzed for several parameters including nutrients, chlorophyll *a*, bacteria, metals, dissolved oxygen, temperature, salinity, transparency, and turbidity.

The Charles River Watershed Association (CRWA) and the Massachusetts Water Resource Authority (MWRA) also routinely sample the Basin for several water quality parameters. CRWA samples quarterly at four locations in the Basin, while the MWRA has sampled two locations multiple times per month throughout the year for nutrients and chlorophyll *a* which are parameters of concern for this section of the permit. Both CRWA and MWRA collect data in accordance with accepted QAPPs. Mirant also has conducted water quality monitoring of the Charles River Basin during the summers of 2001, 2002, and 2003. Although Mirant's data were not collected in accordance with approved QAPPs, EPA has considered Mirant's data as supporting documentation that collaborates the Basin's water quality conditions for this permit.

For the purpose of this permit, the following discussion primarily relies on EPA's data because EPA's monitoring program provides the greatest spatial coverage of the Basin (ten stations) during the critical summer months for the parameters of concern. A review of the CRWA, MWRA, and Mirant data reflect water quality conditions that are consistent with conditions reflected by EPA data.

Table 1 summarizes EPA's measurements of summer season ambient chlorophyll *a*, total phosphorus (TP), total nitrogen (TN), and secchi disc depths at various locations in the Basin in the years 1998 through 2002. Summer season total nitrogen data are not available for 1998 - 2001. For the purpose of presenting this information, the Basin is divided into three segments as identified in Table 1. The values presented for each segment represent data from multiple stations (see table notes). Figure 1 shows the locations of EPA water quality monitoring stations in the lower Basin. Core monitoring stations which have been sampled every year beginning in

1998 are identified with "CRBL" preceding the station number (e.g., CRBL06). Additional water quality monitoring stations that were sampled during the peak 2002 recreational season only to support development of the TMDL are identified with "TMDL" preceding the station number (e.g., TMDL21).

As indicated, the values for each of the parameters tend to range considerably during the summer season. Such variability in concentrations is not unusual for river systems like the Charles River that experience wide variations in flow. The high chlorophyll *a* values observed indicate that severe algal blooms have occurred each year in the lower Basin. Examination of the individual EPA data shows that the most severe blooms typically occur in late July and August when low river flow conditions exist and when light transmission and water temperatures are highest. Also, the magnitudes of TP and TN data observed throughout the Basin indicate that nutrient levels exist at times to support excessive algal growth in the Basin.

Table 1. Summary of Selected EPA Summer Water Quality Data for the Charles River Basin (1998-2002)

Chlorophyll a (ug/l)					
Location	1998 low-high (mean)	1999 low-high (mean)	2000 low-high (mean)	2001 low-high (mean)	2002 low-high(mean)
Longfellow Bridge	7-52 (23)	11-116 (45)	9-51 (36)	8-53 (28)	2-65 (23)
BU Bridge-Harvard Bridge	7-78 (29)	13 - 77 (44)	15-73 (49)	7-56 (33)	2-59 (35)
Watertown Dam-BU Bridge	4 -21 (10)	9 - 50 (25)	3-95 (23)	2-49 (13)	2-49 (16)
Total Phosphorus (ug/l)					
Longfellow Bridge	80-200 (120)	25-120 (60)	25-74 (60)	40-120 (70)	28-91 (53)
BU Bridge-Harvard Bridge	80-140 (110)	25-110 (70)	25-180 (100)	50-110 (80)	20-94 (58)
Watertown Dam-BU Bridge	100- 330 (150)	25-100 (60)	25-160 (80)	40-100 (60)	35-87 (66)
Total Nitrogen (ug/l)					
Longfellow Bridge	NA	NA	NA	NA	670 -1860 (1078)
BU Bridge-Harvard Bridge	NA	NA	NA	NA	660 -1850 (1151)
Watertown Dam-BU Bridge	NA	NA	NA	NA	930 -1740 (1253)
Secchi Depth (meters)					
Longfellow Bridge	0.6-1.5 (1.1)	0.9-1.8 (1.4)	1.0-1.7 (1.3)	0.8-1.8 (1.3)	1.1-2.2 (1.5)
BU Bridge-Harvard Bridge	0.6-1.2 (0.8)	0.7-1.7 (1.1)	1.0-1.7 (1.3)	0.6-1.4 (0.9)	0.9-2.2 (1.4)
Watertown Dam -BU Bridge	0.6- 1.3 (0.9)	0.7-1.3 (1.2)	0.8-1.5 (1.1)	1.1-1.4 (1.2)	0.8-1.4 (1.0)

Notes: 1) 1998-2001: Longfellow Bridge values represent data from EPA core monitoring stations CRBL09, 10, and 11; BU Bridge to Harvard Bridge values represent data from EPA core monitoring stations CRBL05, 06, and 07; and Watertown Dam -BU Bridge values represent data from EPA core monitoring stations CRBL02, 03 and 04 (Watertown Dam to Herter Park).

2) 2002: Longfellow Bridge values represent data from EPA core monitoring stations 09, 10, and 11, and TMDL stations 25, 26, and 28; BU Bridge to Harvard Bridge values represent data from EPA core monitoring stations 05, 06,and 07 and TMDL stations21, 22, and 23; and Watertown Dam -BU Bridge values represent data from EPA core monitoring stations CRBL02, 03 and 04 (Watertown Dam to Herter Park).

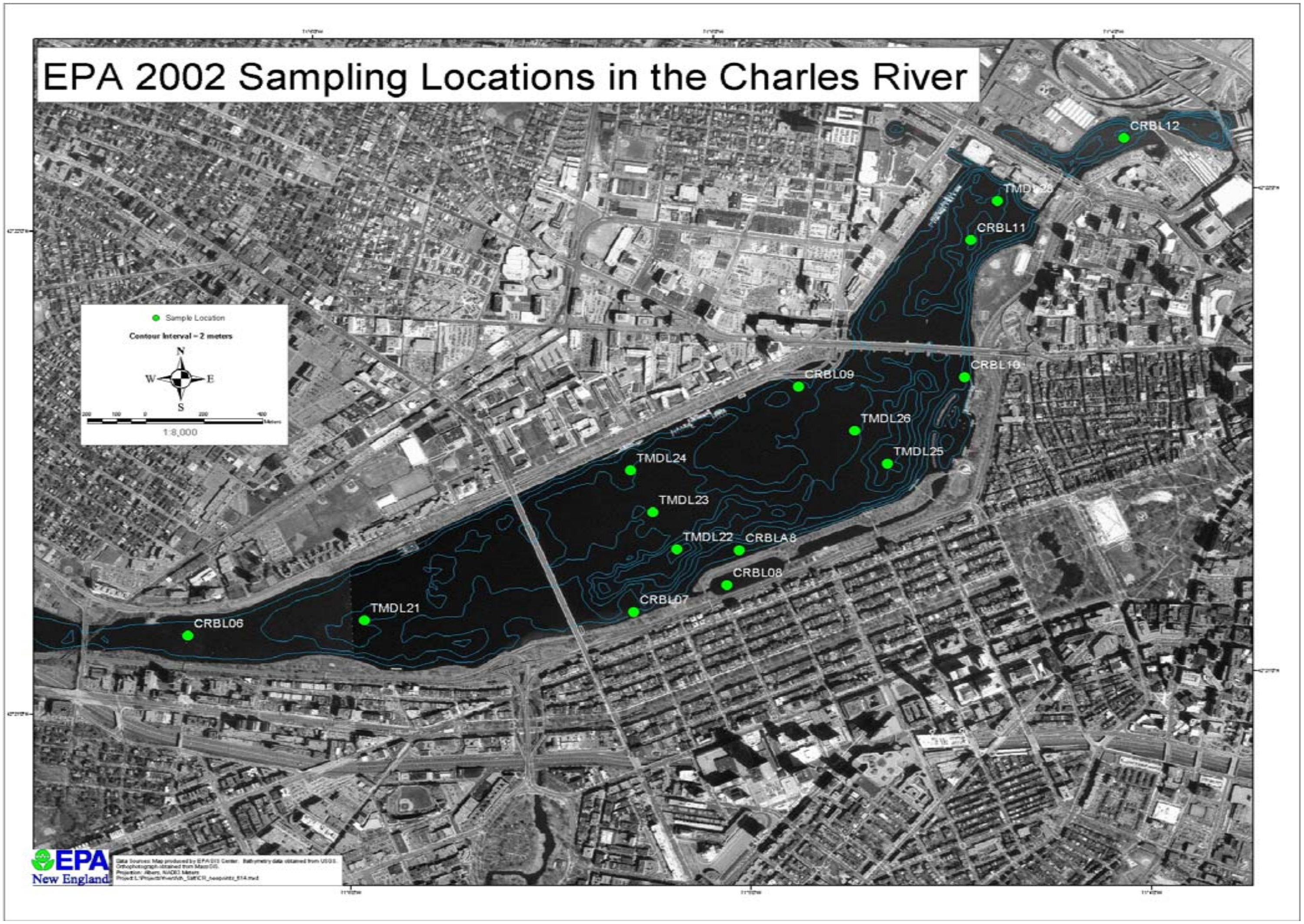

Figure 1. EPA Water Quality Monitoring Stations - Lower Charles River Basin

Algal growth is primarily a function of nutrient availability, light, and temperature (Chapra, 1997). Of all the nutrients that are needed by algae (i.e., carbon, oxygen, nitrogen, phosphorus, silica, sulfur, and iron), phosphorus and nitrogen are typically in limited supply. The relative amounts of phosphorus and nitrogen in aquatic systems determine which of these nutrients is in more limited supply for algal growth. Depending on the time of year and other environmental factors, either phosphorus or nitrogen may limit algal growth.

In the Basin, based on measured amounts of nitrogen and phosphorus, phosphorus is the more limiting nutrient for algal growth. However, during the early summer period (June to early July), TP and orthophosphate are typically at such elevated levels that algae are likely limited by other factors; possibly light attenuation, consumption by zooplankton, or water temperature. Orthophosphate is the form of phosphorus that algae can directly use for growth and its concentration can be an indication of whether phosphorus is in limited supply at the time of the sampling. During the early summer, orthophosphate levels are typically much higher in the Basin than during mid to late summer when conditions are more favorable for algae growth and nutrients are in higher demand. The higher nutrient levels and lower chlorophyll *a* levels in the early summer period indicate that other factors such as light or zooplankton grazing may be controlling the amount of algae in the Basin.

During the early summer period, water in the Charles River is highly colored or "stained" by dissolved organic matter. The presence of dissolved organic matter and color in the Charles River reduces light transmission through the water column and thus, affects algal growth. A likely source of the color (staining) is the dissolved organic matter from the extensive wetland areas adjacent to the river in the upper watershed. As the summer progresses, watershed contributions of flow and pollutants (including nutrients and dissolved organic matter) to the Charles River decline significantly resulting in improved water clarity and much lower nutrient levels in the Basin. Consequently, phosphorus, rather than light, is typically the limiting factor on algal growth during the mid to late summer period.

Usually the most severe algal blooms occur in late July and August when water temperatures are higher, water clarity is improved, and phosphorus availability is limiting algal growth. A review of available water quality data indicates that the increase in bloom severity coincides with declines in water color (increased water clarity) and increasing water temperatures. Decreases in TP and increases in bloom severity also coincides with declines in river flow which increases the hydraulic residence time in the lower Basin and allows for more time for algae to grow and accumulate in the Basin. Seasonal reduction in TP and water color are likely to be due to reductions in flow and pollutant load contributions from the watershed.

Figure 2 presents the seasonal trend of several water parameters and river flow observed in the lower Charles River Basin during the sampling season in 2002. The seasonal trends depicted for the summer of 2002 are generally consistent with seasonal trends observed for the same parameters during the other years that EPA has monitored the lower Basin (1998-2001). As indicated, true color, TP, and orthophosphate are higher while chlorophyll *a* is lower during the

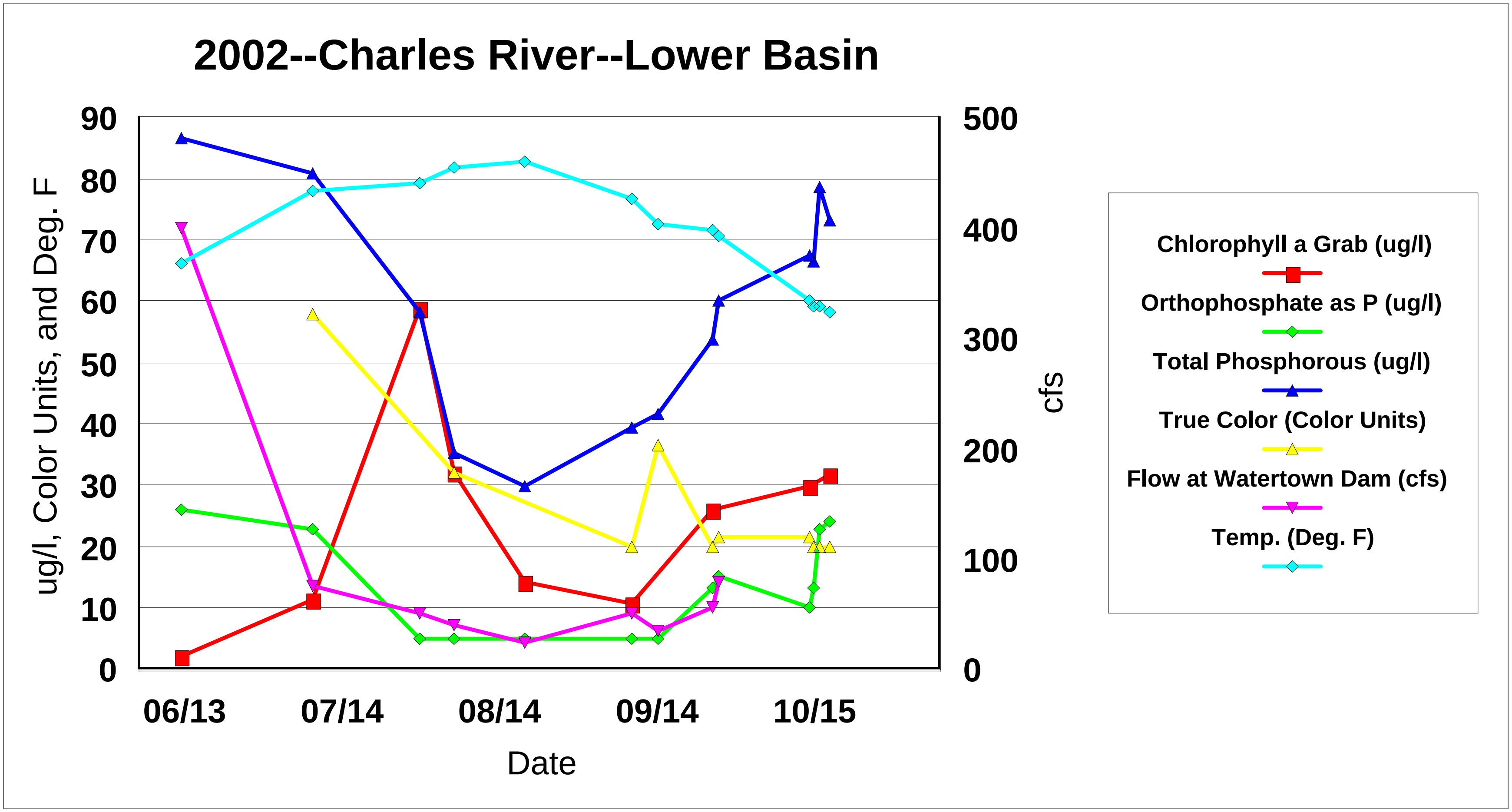

Figure 2 Notes: Plots are based on arithmetic means of data from EPA monitoring stations CRBL07, A8, 09, 10, 11, TMDL21, 22, 23, 24, 25, 26, and 28.

Figure 2. Recreational Season 2002 Water Quality Data for the Lower Charles River Basin

early summer period. As the summer progresses true color and river flow decline and chlorophyll *a* increases dramatically.

Figure 2 illustrates the portion of the summer when phosphorus becomes the limiting factor to algae growth in the lower Basin. Note the similarity between the shape of the chlorophyll *a* and TP curves once true color falls below 40. As TP concentrations decline in the lower Basin so do the chlorophyll *a* concentrations. Another indication that phosphorus is limiting algal growth during mid to late summer is revealed by the orthophosphate data and the orthophosphate curve shown in Figure 2. As the summer progresses, orthophosphate concentrations (the form of phosphorus that the algae use directly) typically fall below the very low analytical detection level used by EPA (5 to 8 ug/l), indicating that algae are readily consuming available phosphorus. This pattern of orthophosphate dropping below the minimum detection limit during mid to late summer when algae blooms are typically most severe has occurred in every year that EPA has monitored the Basin.

Chlorophyll *a*, TP, TN, and secchi depth are parameters of particular interest for the Basin and this permit because they are commonly used to classify the trophic state of fresh water lakes and impounded river systems. The trophic state is a description of the biological condition of a waterbody. There are three general trophic states: (1) oligotrophic, indicating low plant biomass; (2) mesotrophic, indicating intermediate plant biomass; and (3) eutrophic, indicating high plant biomass. The term eutrophication indicates that a waterbody is becoming more productive (i.e., producing more plant biomass). Cultural eutrophication, or accelerated eutrophication, indicates that a waterbody is producing more plant biomass as a result of anthropogenic activities such as the direct discharge of pollutants (e.g., nutrients) to the waterbody (EPA, 2000).

As discussed above, phosphorus and nitrogen are essential nutrients for plant growth and are often used as causal indicators of eutrophication because their presence results in plant growth. Chlorophyl *a* and secchi depth are response indicators that reflect the presence of algae. Chlorophyl *a* is a photosynthetic pigment in the algae cell and, therefore, is a direct indicator of algal biomass. Secchi depth is a measure of water clarity and reflects the presence of algal and non-algal particulate matter suspended in the water column (EPA, 2000).

There are a number of water quality problems commonly associated with excessive plant growth (primary production) in eutrophic waters. Water quality problems common to eutrophic waters include poor aesthetic quality, low dissolved oxygen in the hypolimnion (bottom waters), and undesirable alterations to species composition and the food web (Chesapeake Bay Program, 2001).

Trophic states of aquatic systems are based on values of key variables. Tables 2, 3, and 4 summarize values of water quality variables associated with the trophic status of many fresh water lakes as reported by several researchers. Note that Table 2 provides mean values for chlorophyll *a* while Table 3 provides peak chlorophyll *a* values. Peak chlorophyll *a* values are important because they are indicative of instantaneous bloom conditions which might impair both recreational and aquatic life uses in the waterbody. Also shown in Tables 3 and 4 are values of trophic indicators for the lower Basin based on EPA's water quality monitoring data.

Table 2. Summary of Fresh Water System Trophic Status as Characterized by Mean Chlorophyll *a* Concentrations (ug/l) (1)

Trophic Status	Wetzel (2001)	Ryding and Rast (1989)	Smith (1998)	Novotny and Olem (1994)
Eutrophic	>10	6.7 - 31	-----------	>10
Mesotrophic	2- 15	3 - 7.4	3.5 - 9	4 - 10
Oligotrophic	0.3 - 3	0.8 - 3.4	----------	< 4

(1) Table taken in part from Working Draft Chesapeake Bay Chlorophyll *a* Criteria Document, July 3, 2001.

Table 3. Fresh Water Trophic Status Boundary Values for <u>Peak</u> Chlorophyll *a* (ug/l) as Reported by Ryding and Rast (1989) and Peak Chlorophyll *a* (ug/l) observed in the Lower Charles River Basin.

Trophic Status	Peak Range	Lower Charles River Basin (1998- 2002)
Eutrophic	16.9 -107	51 - 116
Mesotrophic	8.2 - 29	N/A
Oligotrophic	2.6 - 7.6	N/A

Table 4. Ranges Based on Scientists' Opinions (after Vollenweider and Carekes, 1980) and Values for the Lower Charles River Basin for the 2002 Recreational Season.

Variable	Oligotrophic	Mesotrophic	Eutrophic	Lower Basin 2002
Total phosphorus (ug/l) mean range (n)	 8 3 - 18 (21)	 27 11 - 96 (19)	 84 16- 390 (71)	 51
Chlorophyll a (ug/l) mean range (n)	 1.7 0.3 - 4.5 (22)	 4.7 3 - 11 (16)	 14 2.7 - 78 (70)	 14
Peak chlorophyll a (ug/l) mean range (n)	 4.2 1.3 - 11 (6)	 16 5 - 50 (12)	 43 10 - 280 (46)	65
Secchi depth (meters) mean range (n)	 9.9 5.4 - 28 (13)	 4.2 1.5 - 8.1 (20)	 2.4 0.8 - 7.0 (70)	 1.4

Notes: (1) Means are geometric annual means (log 10), except peak chlorophyll a.
(2) 2002 dry weather sampling results from EPA monitoring stations CRBL07, A8, 09, 10, 11, TMDL21, 22, 23, 24, 25, 26, and 28.

Based on the high peak chlorophyll *a*, low secchi depths, and elevated nutrient measurements observed in the lower Basin (see Table 1), the Charles River Basin clearly falls into the eutrophic category. The elevated levels of nutrients and algae chlorophyll *a* also indicate that the Basin is undergoing cultural eutrophication from excessive pollutant loading.

Other Important Water Quality Characteristics of the Basin. Water quality data collected in the Basin reveal important characteristics that are common to impounded and stratified systems and relevant to the facility's permit. First, the data show that water quality progressively improves starting at the Boston University (BU) Bridge and moving downstream. EPA data for several parameters (e.g., secchi depth, solids, chlorophyll *a*, and bacteria) collected at stations located between the BU Bridge and the Museum of Science (CRBL06, 07, A8, 09, 10, and 11) indicate progressively improved water quality the further downstream one moves from the BU Bridge. The best water quality observed in the lower Basin regularly occurred at station CRBL11 located between Longfellow Bridge and the Museum of Science (EPA data, 1998-2002). It is important to note that this lower portion of the Basin provides for intensive recreational use (both contact and non-contact). Also, the permittee's existing thermal discharge and the site where the permittee has proposed to construct the diffuser is located in this area.

The improving trend in water quality between BU Bridge and the Museum of Science is demonstrated by EPA water quality data collected on the same dates at monitoring stations CRBL06 (400 meters downstream of BU Bridge) and CRBL11(between Longfellow Bridge and the Museum of Science) (EPA data, 1998-2002). A comparison of chlorophyll *a* data between the two sites show that chlorophyll *a* was higher at the upstream station, CRBL06, for 72% (21 of 29) of the paired observations. Chlorophyll *a* at CRBL06 was on average 39% (15 ug/l) higher than at CRBL11 for those sampling days when CRBL06 had a higher chlorophyll *a*. These chlorophyll *a* data are significant because they show that under current conditions, the concentration of algae downstream of Longfellow Bridge is typically more than one-third less than the concentration of algae in the upstream part of the lower Basin.

A similar comparison was conducted using secchi depth data collected at the same two locations. The results show that secchi depths at CRBL06 were never higher than the corresponding values at CRBL11. The secchi depth at CRBL11 was on average 45% or 1.4 feet greater than the corresponding value at CRBL06, indicating that the water clarity downstream of Longfellow Bridge was consistently better than the upstream portion of the lower Basin. To some extent, secchi depth is indicative of eutrophication, as algal concentration effect water clarity.

The improving trend in water quality conditions beginning at BU Bridge can be explained by the change in morphology of the Basin. Downstream from the BU Bridge, the Basin widens and deepens. As a result, the Basin is functionally more like a lake than a river. Ninety percent of the Basin's entire volume is accounted for in the segment downstream from the BU Bridge (Breault, 2002). The greater volume of the lower Basin causes flow velocities to decline and travel times (retention times) to increase, which in turn increases sedimentation rates. Using a mean summer (July - September) flow in the Charles River of 121 cubic feet per second (Socolow, 2002) the retention time in the lower Basin downstream from BU Bridge is 35 days, which allows for algae blooms to become well-established. Detailed mapping of sediment thickness in the Basin by the United States Geological Survey (USGS) shows that the greatest accumulations of soft sediments (thickness of 3 to 5 feet) in the Basin occur between the Longfellow Bridge and the Museum of Science (Breault, 2000).

Another important water quality condition pertinent to the permit relates to the stratification of the Basin caused by the salinity gradient. Nutrient and chlorophyll *a* data collected during 2002 at the surface and above and below the pycnocline (i.e., top of salt water layer) indicate that there was very little transfer of pollutants from the bottom, higher salinity layer to the upper water column. The data indicate that the upper water column, above the salt water layer, was well-mixed, and that the bottom salt water layer contained very high levels of nutrients. During the August and September 2002 period, when algal growth was at its peak in the Basin and also limited by the availability of phosphorus, TP in the bottom salt water layer was as high as 1620 ug/l (approximately 37 times higher than TP in the upper water column). Furthermore, almost all of the phosphorus measured in the bottom layer was orthophosphate, the form that algae can readily use. In effect, the stratification caused by the salinity gradient was preventing nutrients from mixing into the upper water column where they could fuel algal blooms.

The very high levels of nutrients in the lower water column are due in part to the release of nutrients from the bottom sediments. Results of the USGS sediment study indicate that the sediments in the lower Basin are high in organic carbon and phosphorus content (personal communication R.Breault, USGS). USGS's measurements of nutrient flux rates (amount of nutrients released from sediments) from the Basin's sediments showed that the rates are substantially higher under anoxic (devoid of oxygen) conditions than under oxic (oxygen present) conditions (USGS, 1999). For example, orthophosphate flux rates were up to 197 times higher during anoxic conditions when compared to rates measured under oxic conditions. Generally, DO levels need to be above 2 mg/l in order for phosphorus flux rates to decline significantly (ENSR, 2004). This relationship between DO and nutrient sediment flux rates is important for this permit because of the reasonable potential that exists for the operation of the proposed diffuser to introduce additional nutrients into the upper water column through the mixing of the water column (see discussion of Diffuser Effects beginning on page 18). If operation of the proposed diffuser did not raise DO levels above 2 mg/l at the sediment water interface then the amount of nutrients that would be introduced into the upper water column could be substantially higher than if adequate DO is introduced at the sediment water interface. In such a case, the diffuser would serve to dramatically increase algal growth and eutrophication of the Basin during the mid to late summer period.

Excessive Algae and Related Impairments. The high chlorophyll *a* values and low secchi depths (poor water clarity) observed in the Basin are indicative of excessive amounts of algae. Excessive algae results in poor aesthetic quality because of visual impacts such as reduced water clarity and green coloration. Additionally, excessive amounts of algae and/or the presence of noxious algae species may further impair contact recreational uses (i.e., swimming, kayaking, sail boarding, etc.) because of bad odors and skin irritations. Excessive algae also contribute to other water quality problems in the Basin including low dissolved oxygen (DO) in the bottom waters, and high pH or alkalinity. As a result of the excessive amounts of algae in the Basin, the Basin fails to fully support the designated recreational and aquatic life uses as required in the Massachusetts Water Quality Standards (MAWQS)(314 Code of Massachusetts Regulations (CMR)).

Aesthetic Impairments. There are a limited number of references in the literature concerning the relationship between specific chlorophyll *a* levels and aesthetic impacts. Some of the more informative studies involve the analysis of simultaneously collected water quality and user perception data. The results of three "user perception" based studies are summarized below to provide general information concerning the relationship between the magnitude of chlorophyll *a* values and observed aesthetic impairments.

Smeltzer (1992) presents the results of a study conducted by the Vermont Water Resources Board to develop eutrophication standards for Lake Champlain from user survey data. Results from this study indicated that over 50% of the responders found that enjoyment of the lake was impaired when chlorophyll *a* levels were 8 - 11.9 ug/l. The frequency of this response increased to approximately 90% when chlorophyll *a* was greater than 20 ug/l. Vermont ultimately used the results of the user perception study as the basis for adopting numeric phosphorus criteria for Lake Champlain into the Vermont Water Quality Standards. The numeric criteria are the basis for issuance of numerous NPDES permits with phosphorus effluent limitations for facilities that discharge to the Lake Champlain Basin.

As part of a plan to develop numeric water quality criteria, the Vermont Department of Environmental Conservation (VTDEC) conducted a similar analysis using user perception and water quality data collected from 60 inland lakes. The results indicate that between 40% and 60% of the responders (lake users) found water quality to be aesthetically impaired when chlorophyll *a* was 10 - 20 ug/l. (VTDEC, 2002).

Walker (1985) summarizes the following results of another "user perception based" study conducted on 21 reservoirs in South Africa by Walmsley. The "Nuisance Value" categories identified below were taken directly from Walker's paper. It is likely that algal scums observed in the Charles River Basin would be considered an aesthetic impairment.

Chlorophyll a (ug/l)	Nuisance Value
0 -10	No problems encountered
10-20	Algal scums evident
20-30	Nuisance conditions encountered
>30	Severe nuisance conditions encountered

An evaluation of the high chlorophyll *a* levels regularly observed in the Charles River Basin in light of the results of these studies relating user-perceived aesthetic impairments to chlorophyll *a* measurements strongly suggests that the water quality of the Basin is aesthetically impaired. Chlorophyll *a* data collected at EPA monitoring station CRBL11, located between the Longfellow Bridge and the Museum of Science, were analyzed to evaluate the frequency at which certain levels of chlorophyll *a* were exceeded. The data review found that 64%, 45%, and 23% of the 31 chlorophyll *a* observations at station CRBL11 were greater than 20 ug/l, 30 ug/l, and 40 ug/l, respectively (EPA Data, 1998-2002).

Dissolved Oxygen (DO) Impairments. Very low DO levels, typically between 0 to 3 mg/l, have been measured during the summers in the bottom waters of the lower Basin (downstream of Harvard Bridge) (Breault, 2000, EPA, 2002). The low DO is primarily attributed to the lack of vertical mixing in the lower Basin that is caused by the presence of a saline layer of water along the bottom of the lower Basin. The salt water enters the Basin at the New Charles River Dam and migrates upstream as the summer progresses. Because salt water has a higher density than fresh water, the salt water settles in the bottom of the water column, inhibits vertical mixing, and causes the Basin to stratify (Breault, 2000). Oxygen is readily depleted in the bottom layer because of both biological (respiration) and chemical (oxidation) processes and the lack of vertical mixing. Increasing ambient in-stream temperatures will exacerbate DO problems because both respiration and metabolic rates increase with temperature (Chapra, 1997). Algae blooms contribute to the DO problem in the Basin through algal respiration and the decomposition of dead algae that have settled to the bottom. High chlorophyll *a* and associated algal biomass observed in the Basin help to explain why the bottom sediments of the Basin, as measured by the USGS, are high in organic content (personal communication with R. Breault, 2003).

Water Clarity Impairments. Secchi disc depths measured in the Basin frequently do not attain the Massachusetts clarity standard. Secchi depth is an indication of water clarity and represents the depth at which a small black and white disc can be seen from the water surface. Although the clarity standard is in narrative form, Massachusetts uses a secchi depth of four feet (1.2 meters) to assess attainment of the primary contact recreation use (MAEOEA, 2002). Based on a review of secchi depth data collected at sampling stations CRBL06 (downstream of the BU Bridge), CRBL07 (downstream of the Harvard Bridge) and CRBL11 (between the Longfellow Bridge and the Museum of Science), only 25%, 53%, and 76%, of the observations, respectively, attained the four-foot criterion. Suspended algae in the water column is partially responsible for the poor water clarity because of light absorption and light scattering in the water column (Wetzel, 1983).

pH Impairments. A review of EPA's core monitoring data indicate there were numerous measured exceedences of the Massachusetts pH criteria in the lower Basin. The observed pH often exceeded the 8.3 criteria value during times when chlorophyll *a* levels were high in the Basin. Continuous monitoring of pH and DO show that the pH exceedences coincide with supersaturated DO conditions, which indicates that algal photosynthesis is consuming carbon dioxide from the water and causing the pH to rise.

Development of the Draft Permit to Address Eutrophication of the Lower Charles River Basin

As discussed above, the Charles River Basin in the vicinity of the Kendall Square Station is eutrophic and experiencing accelerated eutrophication due to human activities. As a result, there are a number of water quality problems related to algal blooms that impair both recreational and aquatic life uses. The severity of algae blooms in the Charles River Basin are believed to be the result of a combination of several factors, including: (1) excessive nutrient levels from watershed sources; (2) long retention times caused by the presence of the New Charles River Dam; (3) minimal shading of sunlight; and (4) warm river temperatures.

Throughout the development of the draft permit, EPA has provided written comments to the permittee expressing concerns related to operation of the upgraded Kendall Square Station facility including the proposed diffuser and the potential for further eutrophication of the lower Basin. These comments have stated that safeguards are necessary for the facility to prevent its operation from causing or contributing to noticeable increases in both the severity and duration of algal blooms in the lower Basin. Operational safeguards are included in the draft permit in the form of in-stream temperature limits designed to protect the balanced indigenous populations of aquatic life (e.g., fish) in the Basin. EPA believes that the in-stream temperature limits included in the permit to protect fish populations are established at levels that also minimize the likelihood that the facility's corresponding thermal load will cause or contribute to eutrophication of the Basin. Another safeguard implicit in the permit is EPA's proposal to not permit the diffuser outfall. Finally, monitoring requirements are required to provide EPA with information that can be used to assess whether the upgraded facility is contributing to eutrophication and related recreational and aquatic life use impairments in the lower Basin.

During the development of the eutrophication-related portion of the draft permit, EPA evaluated potential effects to the lower Basin for both the operating conditions as proposed by the permittee, as well as for conditions that were determined by EPA to be necessary for other reasons (e.g., protection of fish populations). Based on the known relationship between temperature and algal growth rates (discussed below), EPA has determined it is possible that during certain critical periods of the growing season (i.e., mid to late summer), thermal loading from the Kendall facility may contribute to high algae levels in the downstream portion of the Basin. That is, it is reasonable to conclude that during these critical periods, the full permitted thermal discharge from the facility without the proposed in-stream temperature limits to protect the balanced indigenous population has the reasonable potential to cause or contribute to an excursion of those MAWQS criteria that are relevant to eutrophication and related water quality impairments (e.g., aesthetics, DO, and pH).

The upgraded facility has the capacity to substantially increase the thermal load to the lower Charles River Basin and raise river temperatures. For example, as a result of the upgrades at the facility and assuming full permitted thermal discharge, the river may receive more than a 500 percent increase in thermal load when compared to the actual average monthly heat load discharged in the recent past (e.g., August 1998). It is difficult to accurately predict how much river temperatures will increase as a result of the operation of the upgraded facility without the benefits of a validated hydro-thermal model. However, based on a review of river temperature and thermal loading data collected by Mirant on August 18, 1999, it is clear that the thermal discharge from the facility caused water temperatures in the lower Basin to increase by at least 4 ºF. This observed increase was associated with a daily average thermal load of 250 MMBTU/hr, only 45% of the full permitted load of 556 MMBTU/hr (Mirant, 2001). The likely increase in Basin temperatures associated with full permitted thermal load and the resulting effects on algal growth rates make it necessary to include permit conditions to protect the lower Basin from an increase in algae and/or the proliferation of noxious species.

There are two primary issues related to accelerated eutrophication of the lower Basin and the operation of the upgraded facility as proposed by the permittee: (1) the higher water temperatures in the lower Basin from the substantial (500+ %) potential increase in thermal load of the upgraded facility may worsen algal blooms and result in an undesirable shift in species composition; and (2) the operation of the proposed diffuser may introduce into the upper water column dissolved nutrients that have been released from bottom sediments, and thereby fuel algae blooms.

Temperature Effects on Algal Growth Rates. One of EPA's primary concerns relating to the operation of the upgraded facility and eutrophication is the relationship between temperature and the growth of algae. Without other operational constraints, the facility has the potential to significantly increase the temperature of the Basin. There is extensive information in the literature concerning the influence of temperature on phytoplankton growth. Canale and Vogel (1974) summarize the findings of numerous investigators and present temperature data and corresponding calculated specific growth rates for several species from four groups of phytoplankton. The data illustrate that growth rates for individual species vary with temperature. For example, the calculated specific growth rate for the diatom *Asterionella formosa* varied from 0.69 day $^{-1}$ at 10 degree Celsius (ºC) to an average of 1.67 day $^{-1}$ at 20 ºC. In the higher temperature range, growth rates for the blue-green species *Anacystis nidulans* varied from 2.64 day $^{-1}$ at 25 ºC to an average of 4.4 day $^{-1}$ at 30 ºC and to 11.0 day $^{-1}$ at 40 ºC.

Canale and Vogel plotted the growth rate data for the four groups as a function of temperature, and, although the authors reported that the data showed some scatter, they determined that major trends could be estimated for each group. These trends were interpreted as curves and are illustrated in Figure 3. As indicated, there is a positive correlation between growth rate and temperature for each of the groups. Also indicated by the curves shown in Figure 3, as well as the individual data summarized in Canale and Vogel's paper, is the competitive advantage that some species, particularly blue green algae, have at higher temperatures. As shown on figure 3, the maximum growth rate vs. temperature curve for blue-greens has a steeper slope than the curves for other major algae groups at temperatures above 25 ºC, indicating that the rate of change in growth rate increases more rapidly than the other groups at elevated temperatures.

During the summer of 2002, EPA conducted algal analyses to document species composition in the lower Basin. The data show that the composition of the algal community shifted from predominantly diatoms in early summer to blue greens as the summer progressed (EPA, 2002). The presence of blue green species in the Basin is undesirable because blooms of these species often result in objectionable aesthetic impacts and negative alterations to the aquatic ecosystem. For example, many blue green species form noxious scums, are toxic to aquatic life, and are inedible to zooplankton which ultimately impacts the food web (Chapra, 2003).

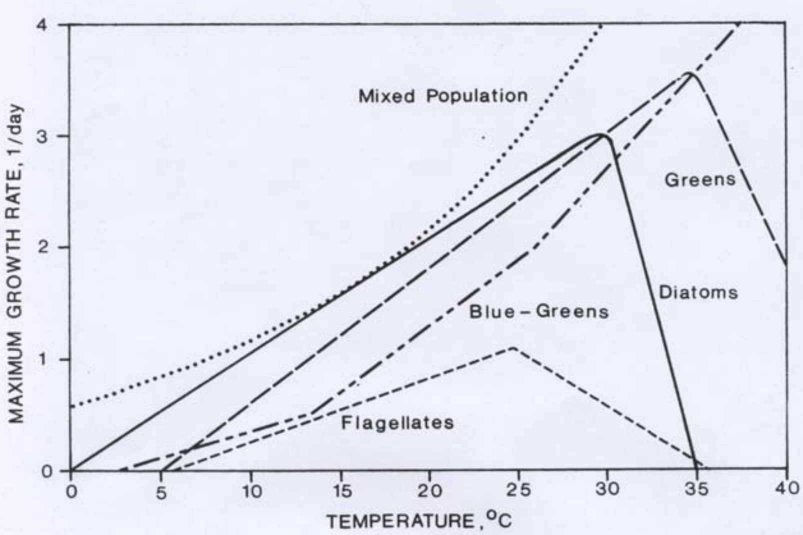

Figure 6-3. Temperature-growth curves for major algal groups (from Canale and Vogel, 1974).

Figure 3. Temperature-growth curves for major algal groups from Canale and Vogel, 1980.

It is necessary to include monitoring provisions in the permit to collect information from the lower Basin in order to assess whether higher sustained temperatures of up to 28.3 ºC (83 ºF) during the summer season in the lower Basin caused by the facility's discharge (which the draft permit allows for) is resulting in more extensive algal blooms and/or increased blue green algae. Typically, a water quality model that simulates algal dynamics would be used to evaluate this issue. However, for reasons discussed below, a calibrated water quality model is not presently available to determine whether thermal loadings from the facility consistent with achieving in-stream temperature limits would cause or contribute to algal blooms in the lower Basin.

Background for Permit Development to Address Eutrophication. In December of 1999, EPA reviewed the *Draft Environmental Impact Report (EIR), Kendall Square Station Equipment Upgrade Project, Cambridge, Massachusetts,* dated November 1999 and provided comments concerning the operation of the facility and its potential to exacerbate eutrophication in the

Basin. EPA provided more explicit and detailed comments on this issue during subsequent reviews of the Final EIR (June 2000) and materials associated with the NPDES Permit application (July 2001 and December 2001). The permittee has failed to demonstrate quantitatively that operation of the upgraded facility and proposed diffuser will not further degrade the Charles River Basin.

As discussed below, the permittee has attempted to explain why algal blooms in the lower Basin might not be affected, or might possibly be reduced, as a result of the operation of the their upgraded facility. These explanations, however, have inadequately addressed EPA's concerns that a reasonable potential exists for the proposed operation of the facility to worsen algal blooms in the Basin and thereby cause further degradation of water quality. In EPA's June 23, 2000 comments, the permittee was informed that it "should demonstrate through quantitative modeling or some other scientifically defensible method, that the severity of blooms will lessen or, at a minimum, not be exacerbated as a result of the Project." Despite this comment, the permittee's responses to EPA's concerns have been qualitative, as discussed in detail below.

The permittee's position with regard to the potential impacts of the proposed operation of the upgraded facility on algal growth in the Charles River Basin has three main points: (1) there is no demonstrated effect of temperature on algal levels in the Basin; (2) the passage of algae through the facility's condensers cause thermal stress that will inhibit algae growth in the Basin; and (3) operation of the diffuser will reduce algal levels in the Basin.

Temperature Effects. The permittee's position that temperature is not affecting algal levels in the Basin is based on a comparison between ambient water temperature and chlorophyll *a* data from the entire Basin (Watertown Dam to the Museum of Science). Such an analysis is flawed because it is virtually impossible to isolate temperature as a sole influencing factor on algal growth in natural waters (Goldman, 1981) and it ignores the extensive information in the literature that documents a positive correlation between temperature and algal growth rates when other factors (i.e., nutrient and light) influencing algae growth were held constant. The permittee has failed to provide convincing evidence that algal levels are not influenced by temperature in the Basin. Furthermore, existing water quality data are not reflective of potential future conditions when the facility is discharging at or near full permitted thermal load.

As previously discussed, water quality conditions that directly and indirectly influence algal growth vary throughout the Basin and furthermore vary throughout the sampling season. Nutrient availability can vary significantly within the Basin because of local source inputs and sedimentation rates in the lower Basin which increase in the downstream direction (i.e., more algae and phosphorus will settle out of the water column in the lower Basin than upstream). Also, water clarity which affects light attenuation varies throughout lower Basin on any given day, as well as seasonally. Light intensity and duration vary widely on a daily and seasonal basis. For the purpose of assessing the relationship between temperature and chlorophyll *a*, it is invalid to combine data from multiple stations in the Basin that were collected at different times of the day, at different times during the growing season, and when pertinent water quality conditions (e.g., nutrient availability, clarity) were different. In order to meaningfully evaluate the effects of temperature on algae in the lower Basin, a water quality model or other quantitative analysis is necessary that accounts for all of the major factors (i.e., nutrient availability, light intensity, water clarity, etc.) that influence algal growth in the lower Basin. Therefore, EPA has concluded that the permittee has not adequately demonstrated that the amount of algae in the lower Basin will not increase as a result of increases in Basin temperature.

Thermal Stress from the Facility. The permittee provided a paper by Gurtz and Weiss entitled *Response of Phytoplankton to Thermal Stress*. The paper presents the results of a study that measured primary productivity of algae after being subjected to rapid changes in temperature (delta Ts of 10, 20, and 30 ºF) from passage through condensers at a power plant. The results indicate that algal growth was inhibited, and that the magnitude of the effect decreased over time. Based on the results of this study, it is reasonable to assume that algae passing through Kendall Station's condensers would experience some level of shock that might temporarily effect growth; however, to assess the net impact on the overall community, a validated water quality model capable of simulating both the amount of algae being circulated through the facility and the total amount of algae in the lower Basin is necessary. In addition, a validated water quality model is needed to simultaneously evaluate the effect of increased growth rates due to temperature increases on algae that do not pass through the facility. EPA does not have sufficient data or modeling to conclude that overall algae levels in the Basin will be noticeably reduced as a result of heat stress.

Diffuser Effects. The permittee has proposed to construct a diffuser outfall pipe along the bottom of the Lower Charles River Basin to discharge up to 40 million gallons per day of non contact cooling water with a temperature not to exceed 105 ºF. The proposed diffuser pipe is 42 inches in diameter, would extend 738 feet along the bottom of the Charles River between Longfellow Bridge and the Museum of Science and would include 16 discharge ports (Mirant, July 2001). Operation of the diffuser would more effectively disperse heat pollution to the Basin through induced vertical mixing that would increase the Charles River's assimilative capacity for heat pollution by increasing available dilution.

It has been largely accepted among the review agencies that the vertical mixing resulting from operation of the diffuser will disrupt the strong vertical stratification associated with the presence of a heavier salt water layer along the bottom of the river. The salt water enters the Basin primarily through the boat locks at the New Charles River Dam. As a result of the vertical stratification or lack of vertical mixing, the dissolved oxygen levels in the bottom salt water layer are typically very low and unsuitable for most desirable aquatic life including fish. The permittee asserts that the vertical mixing resulting from operation of the diffuser will introduce enough dissolved oxygen into the water such that most of the water column will achieve MA's minimum dissolved oxygen criterion of 5.0

mg/l. The permittee also asserts that the increase in DO will provide for an increase in habitat that helps to offset the deleterious impacts associated with the thermal discharge.

EPA has provided comments to the permittee concerning the potential for the operation of the diffuser to cause or contribute to exceedences of MA Water Quality Standards including nonattainment of the aesthetic and eutrophication standards. As discussed in detail below, EPA believes there is a reasonable potential for the operation of the diffuser to reduce water clarity and worsen algal blooms because of additional nutrient loading from the bottom waters. This portion of the fact sheet addresses only eutrophication-related issues associated with the operation of the diffuser. In addition to concerns with increased nutrient loading to the upper water column, there remain questions concerning the operation of the diffuser and the fate of toxic contaminants known to be present in the benthic sediments, as well as the effects of higher salinities on fresh water fish species in the upper water column.

EPA's position is that a validated water quality model of the Basin that is linked to a validated hydro-dynamic model is needed to simulate these conditions and evaluate the overall effects of vertical mixing on algal abundance in the lower Basin. EPA has requested such a water quality model from the permittee, but the permittee has not provided an acceptable model. As a result of unresolved concerns, EPA proposes not to authorize the discharge of non-contact cooling water through the proposed diffuser at this time. In the event the permittee presents results of modeling acceptable to EPA, and those results indicate that operating the diffuser would not cause, contribute to, or exacerbate eutrophication of the lower Basin, EPA will re-visit this proposal.

As an alternative to developing an acceptible water quality model of the Basin, the permitee proposed in a December 17, 2003 letter to EPA and MADEP an approach to monitoring and responding to potential diffuser impacts. EPA's review of this approach is discussed below starting on page 31.

The permittee maintains that the operation of the diffuser and the resulting mixing will reduce algae levels because of (1) higher salinity in the photic zone; (2) entrainment of algae into the bottom waters and out of the photic zone; (3) reductions in nutrient availability associated with oxidation of soluble nutrients in the bottom waters and their resulting precipitation from the water column; and (4) surface turbulence caused by the discharge through the diffuser will help retard development of algal masses in the vicinity of the discharge.

Throughout the permit application process, the permittee has referred to the Metropolitan District Commission's (MDC) *Charles River Artificial Destratification Project* (1981) as its primary evidence that the diffuser will benefit the Basin and not worsen algal blooms. EPA disagrees with the permittee's assumption that the mixing patterns and water quality conditions that occurred in the lower Basin when the MDC's aerators were operating would be representative of conditions that would result from the operation of the proposed diffuser for today’s conditions in the Basin.

First, the mechanics of inducing vertical mixing using the aerators and the proposed diffuser are distinctly different. The aerators released pressurized air from the bottom at discreet locations in the lower Basin while the proposed diffuser would discharge heated water almost horizontally along the bottom of the lower Basin. Second, as discussed below current water quality conditions in the Basin (surface nutrient and salinity levels) are dramatically different from conditions that occurred approximately 25 years ago when the destratification project was underway. Finally, unlike the MDC aerators, the heated discharge (105 ºF) associated with the proposed diffusers will affect a number of biological and chemical processes including increased metabolic and degradation rates.

Despite these important differences between the aerators and the proposed diffuser, EPA believes the water quality data associated with the MDC’s destratification project does provide some insight into water quality conditions when the Basin was destratified and surface salinities were much higher. EPA has reviewed the MDC data and has determined that operation of the aerators and the resulting destratification did not decrease algal blooms or reduce nutrients in the surface layer of the Basin. On the contrary, EPA believes that the MDC data support the following conclusions:

> (1) Severe algal blooms existed in the lower Basin even when surface salinities were at or above salinity levels that are likely to occur if the Basin was destratified today;
>
> (2) Limited algal data indicate that algal levels increased during the period when the aerators were operational and portions of the Basin were well mixed (i.e., destratified); and
>
> (3) Prior to and during operation of the MDC aerators ambient phosphorus concentrations in the Charles River Basin were so high that it was highly probable that algal growth was not limited by nutrients but by other factors such as light penetration.

The bases for these conclusions and EPA’s determination that the permittee has not adequately addressed EPA’s concerns or satisfactorily demonstrated that the operation of the diffuser will not contribute to increased algal blooms in the lower Basin are presented below.

<u>Salinity Increases</u>. The permittee has hypothesized in its October 23, 2002 letter that “*higher salinities would prevail throughout the upper water column in the lower basin and would present another potentially limiting factor on growth of the freshwater algal species drifting down the basin.*” However, the permittee has not quantified the probable net effect of increased salinity on the total amount of algal biomass in the Basin nor on the ultimate composition of the algal community. EPA agrees that as long as salt water intrusion continues at the New Charles River Dam, it is reasonable to assume that vertical mixing associated with the diffuser will result in an increase in salinity in the upper water column. EPA also agrees that a change in salinity can affect algal species composition, however, the extent of the effects will depend on the magnitude of salinity in the photic zone.

To accurately predict post-diffuser salinity in the Basin, a validated hydro-dynamic model is needed. Although the permittee prepared a hydro-dynamic model of the Basin, EPA has determined that the model is not acceptable for evaluating receiving water conditions because: (1) a number of EPA's December 2001 comments concerning the model's calibration remain unresolved (discussed below); and (2) despite EPA's request, the permittee has not provided documentation to validate the method used to interface the near field and far field mixing associated with operation of the proposed diffuser. Without model validation, EPA does not have confidence that model output is representative of post-diffuser operation conditions.

Regardless of what the post-diffuser surface salinities might be, the permittee has not provided any information that supports the assertion that algal blooms would be diminished as a result of higher salinities due to increased vertical mixing. More specifically, the permittee has not provided information to quantitatively assess the effects of increased salinity on the composition of the algal community and the overall amount of algal biomass in the lower Basin. Although EPA agrees that the growth or presence of certain resident fresh water algal species may be inhibited by an increase in salinity, this does not mean that there will be an overall reduction in algal biomass. The increase in salinity could simply result in a shift in the composition of the algal community to include species that are tolerant of brackish water. EPA believes that a valid water quality model would be needed to conduct such an assessment.

To gain insight into how an algal community might respond to higher salinities in the Charles River Basin, EPA has estimated the magnitude of surface salinities assuming complete mix conditions and has reviewed historical water quality data. Using salinity data provided by the USGS and river volumes provided by the permittee, EPA has conservatively estimated the surface salinity in the lower Basin for complete mixed conditions to be approximately 6.5 parts per thousand (ppt). This estimate was calculated using the maximum amount of salt measured in the lower Basin (21.52 million kilograms on July 19, 1999-(USGS,2000)) by the USGS during the salt wedge study and the volume of water between Longfellow Bridge and the New Charles River Dam (3.3 million cubic meters- (Mirant, November 6, 2001)). This estimate is believed to be conservatively high since the calculation only uses a portion of the river volume in which the salt is likely to be dispersed and it does not take into account the increased release of salt back to Boston Harbor that would occur as a result of the surface water discharge from the Charles to Boston Harbor.

EPA has reviewed surface DO and salinity data collected in the lower Basin by the MDC during the Artificial Destratification Project conducted from 1976-1980. Although, as discussed above, EPA does not believe operation of the aerators was representative of the potential impacts of the proposed diffuser. The data from the project appear useful for the limited purpose of examining of how increases in surface salinity might affect algae abundance in the lower Basin. Before and after the aerators were online, surface DO levels were frequently well above DO saturation values during the summer period when surface salinities were between 5 and 13 ppt. The "super-saturated" DO levels in the Charles River Basin during this time indicate photosynthetic activity by algae. In a quiescent waterbody like the Charles River Basin DO levels would be at or below saturation if algae were not present. To illustrate conditions that existed in the lower Basin, a series of super-saturated DO and corresponding salinity observations taken from the lower Basin by the MDC are summarized in Table 5. The very high levels of DO super-saturation (up to 197%) and corresponding salinity levels observed indicate that there was high algal activity in the Basin during this period even when surface salinities were elevated (even higher than the estimated salinity level for today's compete mixed conditions).

Table 5. Surface Dissolved Oxygen and Salinity Data for the Lower Charles River Basin (MDC, June 1981)

Date	Aerator Status	Monitoring Station	Temp °F	DO mg/L	DO % Saturation	Salinity ppt
July 14, 1976	Off	2	73.4	11.2	138	10
August 4,1976	Off	3	73.4	16.0	192	5
August 10,1977	Off	2	77.0	10.2	128	5
July 19. 1978	On	2	75.2	14.4	178	6
July 23, 1979	On	2	80.6	11.4	148	6
September 22, 1980	On	2	75.2	15.4	197	13

To provide a sense of the magnitude of algal activity that may have been occurring in the Charles River Basin during this period, DO and chlorophyll *a* data collected from the Basin by EPA on July 30, 2002 are presented in Table 6. As indicated, the corresponding chlorophyll *a* levels increase as percent saturation increase and are very high for the higher DO values. The higher chlorophyll *a* values observed at CRBL06, 09, and 12 are indicative of severe bloom conditions.

Table 6. Select DO Saturation and Chlorophyll a from the Charles River Basin -July 30, 2002 (EPA, 2002)

EPA Monitoring Station	DO mg/l	DO % Saturation	Chlorophyll *a* ug/l

CRBL03	8.8	110	13
CRBL06	11.1	136	49
CRBL12	12.7	160	64
CRBL09	13.5	168	65

The Agencies also reviewed the limited algal data that were collected as part of the MDC monitoring program. The algal data identify family and species as well as the quantity of algae present in surface water samples collected from the lower Basin prior to and during operation of the aerators. Table 7 summarizes these data for the summer months of 1977 through 1980. Concurrent salinity data also are presented in parenthesis for those dates on which both salinity and algal data are available. These data confirm that an algae community tolerant of salinities between 5 and 13 ppt existed in the lower Basin.

Table 7. Summer Algae Data from the Lower Charles River Basin - Summers of 1977-1980 (MDC, 1980)

Month	**Algae Counts in Standard Areal Units per milliliter (Salinity (ppt))**							
	No Aerator		**Aerators On- Line**					
	1977		**1978**		**1979**		**1980**	
MDC sta. (1)	**1**	**3**	**1**	**3**	**1**	**3**	**1**	**3**
June	5380	3180	-	-	17450	8480	2760	2040
	-	-	-	-	4200	6700	-	-
July	-	-	-	-	4580	5100	5340	5620
	-	-	-	-	4760(5)	5560(6)	-	-
August	1920	2600	4440	4500	-	-	2060	2360
			10960	4160	-	-	-	-
September	860	600	2580	2980	1580	2560	4360(13)	5680(13)
	1560	3040	3060	-	-	-	-	-
	-	-	2000	1880	-	-	-	-

(1) MDC Sation 1 is located upstream of the Museum of Science
MDC Station 3 is located just upstream of the Longfellow Bridge

Mixing and Light Limitation. The permittee has failed to quantitatively demonstrate that algae moving out of the photic zone, because of mixing or by discharge into the bottom waters, will result in a reduction of the overall amount of algae in the upper water column. Despite EPA comments (June 2000), the permittee has not considered the possible effect of mixing and the upward movement of algae into the upper water column where light conditions are more favorable for growth. The net effect of mixing on algae levels in the surface water layer will primarily depend on algal transport into and out of the photic zone and the duration of time that algae spend in conditions that favor net growth. Again, a validated water quality model of the Basin is needed to simulate these conditions and evaluate the overall effects of vertical mixing on the algal community.

Furthermore, the MDC data discussed above indicate that severe algal blooms occurred even while the aerators were operating and the water column in the lower Basin was vertically mixed (i.e.,destratified). Although, the MDC data did show that destratification was accomplished, the data do not indicate that algal blooms were reduced while the aerators were in operation. In contrast, the highest algal counts occurred during the three years while the aerators were in use.

Nutrient Availability. The permittee has not demonstrated that the operation of the proposed diffuser will reduce nutrient availability, or addressed EPA's concerns that the diffuser could increase nutrient loading to the surface layer of the lower Basin. As a result, there remains a reasonable potential that the operation of the diffuser will add nutrients to the upper water column where they may be available for uptake by algae.

The permittee has theorized that operation of the diffuser will reduce nutrient availability and thus, reduce the severity of blooms in the Basin. Its position is that the higher DO in the bottom waters (caused by the entrainment of oxygenated surface water through vertical mixing) will cause dissolved phosphorus that has fluxed from the bottom sediments to form insoluble iron salts, thereby reducing nutrient availability for algae. EPA agrees that higher DO in the bottom waters (at least 2.0 mg/l at the sediment water interface) would reduce (but not eliminate) the release of nutrients from the bottom sediments, but disagrees that reductions in nutrient sediment flux rates in the lower Basin during the summer would necessarily translate into reduced nutrient availability for algae.

Extensive water quality data collected by EPA during the summer of 2002 have confirmed that nutrients in the bottom salt water layer, a portion of which are fluxed from the bottom sediments, are accumulating in the bottom salt-water layer and are not likely to be contributing to algal blooms that occur in the upper water column nearer the water surface. The data show that the presence of the salt water layer and the resulting vertical stratification essentially eliminates the bottom sediments as a source of nutrients for the algae. The permitee's theory that the vertical mixing associated with the diffuser would reduce nutrient availability is based on the premise that nutrients from the sediments are contributing to the algal blooms that have been observed to occur during the past several summers when the lower Basin was stratified. As discussed above, EPA's 2002 data confirms that the permitee's premise is erroneous because the data show that most of the nutrients in the bottom waters are trapped in the salt water layer.

Also, in a December 17, 2003 submittal to EPA and MADEP, the permittee states that "phosphorus concentrations are **always** more than sufficient to support whatever algal growth is allowed by other limiting factors" and that "it would be unreasonable to project nuisance algal blooms as a foreseeable result of a hypothetical increase in available phosphorus from operation of the diffuser". To support its position, the permittee developed plots of TP and orthophosphate data vs. corresponding chlorophyll a data for the lower Basin. These plots show a poor correlation between phosphorus and chlorophyll a data which the permittee considers to be evidence that phosphorus never limits algal abundance in the Basin.

EPA believes the permittee's position concerning nutrient limitation is incorrect. As discussed in detail above (see page seven), a more careful examination of available water quality data, indicates that phosphorus availability does typically limit algal abundance in the lower Basin during the mid to late summer period. This period also represents the portion of the summer season that the lower Basin has the best water clarity, the highest water temperatures, and the lowest river flows or longest long retention times (more time for algae to grow) which together create optimal conditions for algal blooms to occur. As a result of these conditions, the addition of nutrients to the upper water column during this period has the potential to worsen algal blooms and therefore, is of particular concern.

For reasons similar to those discussed above in the Temperature Effects Section, the permittee's data analysis is flawed because it fails to consider the spatial and temporal variability of other factors that affect algal abundance in the lower Basin. In order to define a relationship between any one factor and algal abundance, the other important factors should be held constant while the variable of interest is allowed to vary. Such an analysis is very difficult if not impossible to perform when using data from a natural system like the Charles River Basin since all of the important factors that affect algal growth are known to vary considerably both temporally and spatially. For example, light intensity varies considerably throughout a given day and is affected by cloud cover; water clarity (light transmissivity) varies within the lower Basin and is known to vary during the growing season; water temperature also varies seasonally as does the role of zooplankton predation. As a result, it is virtually impossible by using water quality data alone to evaluate the nature of the relationship between nutrients and algae in a given system without taking non-nutrient factors into consideration. The permittee essentially ignored the importance of these other factors in its analysis.

A fundamental problem with the permittee's analysis is that it includes phosphorus and chlorophyll a data that were collected during periods of the growing season (i.e., late spring to early summer and late summer to early fall) when other factors (e.g., light transmissivity, temperature, and zooplankton predation) were likely to be controlling algal abundance in the Basin. The problem with including phosphorus and chlorophyll *a* data that were collected during periods when non-nutrient factors were likely controlling algal abundance is that these data tend to obscure possible correlations between phosphorus and chlorophyll a that could be discerned from a more focused examination of the data. For example, see figure 2 on page nine which shows the obvious relationship between chlorophyll *a* and TP during the mid to late summer period of 2002. Such a relationship is not apparent during the early summer period because other factors (possibly water clarity, temperature, and zooplankton predation) were controlling algal abundance.

The permittee also appears to have included data collected during wet weather events in the analysis. The inclusion of wet weather data is problematic because these data do not reflect the algal response to the high nutrient loading that occurs from wet weather sources. Sampling during and after the monitored storm events occurs before the resident algae population has had time to assimilate the increased nutrient load. Therefore, these data are not representative of algal levels that would occur as a result of high nutrient levels under more consistent dry weather conditions. Also, interpretation of the wet weather data must consider the washout effect that occurs in the lower Basin during and after rain events. EPA wet weather data indicate that a portion of the algae population is flushed out of the Basin during and after rain events. The flushing of algae downstream during and after rain events is likely due to very large increase in river flow and pumping at the New Charles River Dam..

The operation of the diffuser will likely eliminate the vertical stratification by physically mixing the water column. The Agencies believe there is the reasonable potential that the mixing will carry nutrients that are being released from the bottom sediments to the upper water column where they can fuel algal blooms. It is very important to note that the fluxing of nutrients from the bottom sediments is a continuous process and will always occur regardless of the water quality (i.e., DO) conditions of the overlying water. Therefore, the elimination of the stratification will likely result in a net increase of nutrient load to the upper water column regardless of DO in the bottom waters because of vertical mixing. During certain periods of the year when phosphorus is in limited supply and is controlling the amount of algae in the upper water column, any addition of nutrients, no matter how slight, has the potential to increase the severity of algal blooms in the Basin. However, if DO at the sediment-water interface is at sufficient levels to substantially reduce sediment phosphorus fluxing rates, then the increase in phosphorus loading may be so minimal that the affects on water quality may go un-noticed. Again, a water quality model is needed to evaluate water quality impacts associated with operation of the diffuser and de-stratification of the lower Basin. Based on a review of EPA water quality data, phosphorus is typically in limited supply during the months of July, August, and September. EPA data also reveal that these months are when algae blooms are most severe in the Basin.

The magnitude of the bottom sediments as a potential future source of nutrients to the upper water column of the Basin also remains a significant and unanswered question. Although nutrient fluxing from the sediments will occur regardless of the overlying water quality, the amount of DO present at the sediment water interface strongly influences the rate at which nutrients are fluxed. Nutrient flux studies have shown that phosphorus flux rates will decline significantly when the DO at the sediment water interface is above approximately 2.0 mg/l (personal communication with K. Wagner). For DO to reduce nutrient flux rates, the higher DO must occur at the sediment water interface not just in the lower water column. EPA is not confident that the current design of the proposed diffuser would result in attaining sufficiently high DO at the sediment water interface in order to minimize impacts of nutrients being fluxed from the bottom sediments and being introduced into the upper water column. The USGS observed that phosphorus flux rates in the Basin under anoxic conditions were 197 times higher than rates measured when there was ample DO above the sediments. If the operation of the proposed diffuser destratifies the lower Basin and does not increase DO to above 2.0 mg/l at the sediment water interface, then flux rates will remain high and the increase in phosphorus (dissolved and total) loading to the upper water column is likely to be very high.

At the request of the review agencies, the permittee provided predictions of bottom layer DO levels for proposed facility operating conditions using a DO water quality model that was linked to its hydro-dynamic model. As a result of this effort, the permittee asserts that DO levels in most of the lower water column will be above 5.0 mg/l. However, the permitting agencies have little confidence in the output of the DO model because of the concerns with the permittee's hydro-dynamic model addressed above in the discussion on salinity increases, and because of inadequacies with the DO model. The DO model has two key problems that are likely to result in the model over-predicting DO in the bottom layer. First, the model does not account for the effects of temperature on metabolic rates, which increase as temperatures increase. Temperature induced increases in respiration and degradation rates will result in an increase in the consumption of oxygen that will offset increases in DO associated with the introduction of oxygenated surface water into the bottom layer. Despite EPA's comments on this matter, the permittee failed to adjust the sediment oxygen demand (SOD) rate used in the model for future condition scenarios despite its own predictions that the bottom water temperature will increase by approximately 10 ºF.

The second issue relates to the aeration coefficient used in the model which represents the only mechanism used in the model to simulate oxygen entering the water. The Agencies believe the aeration coefficient is overestimated because it was determined through a calibration process that relied on matching model simulated DO to observed super-saturated DO values. The super-saturated DO levels observed in the upper water column reflect photosynthetic activity by algae and are not representative of oxygen transfer rates from the atmosphere to the water (Thomann, 1987). In order to maintain the oxygen levels predicted by the permittee's model, the Basin must support unacceptible levels of algae which would result in water quality impairments and the nonattianment of Massachusetts water quality standards.

The permittee asserts in its June 13, 2003 letter that the MDC data from the destratification project show that the vertical mixing of the water column associated with the aerators reduced nutrient levels in the bottom and surface waters and did not cause blooms to worsen. EPA agrees that the MDC data indicate that the vertical mixing associated with the operation of the aerators reduced the levels of nutrients in the bottom waters. EPA believes that it is possible that the reductions observed in bottom level TP levels could be attributed to increased dilution caused by mixing the entire water column. However, EPA finds the MDC nutrient data for the surface waters to be inconclusive with respect to evaluating the effects of the aerators on surface TP levels during the summer months.

The MDC's summer average TP data for the study period indicates that loadings to the

Charles River Basin at Watertown Dam may have been significantly higher in 1976 and 1977 when the aerators were not on line than in 1979 and 1980 when all of the aerators were operational. MDC data from the Watertown Dam is significant because it is indicative of water quality conditions from the upper watershed and it is not influenced by the aerators. Furthermore, the USGS has determined that TP loadings from the upper watershed measured at the Watertown Dam represent 81 % of the total loading to the Charles River Basin for Water Year 2000 (October 1, 1999 to September 30, 2000) (USGS,2002). Thus, the upstream watershed represents an important source of TP to the Basin. The average summer (July - September) TP concentration at MDC station 7 (Watertown Dam) for 1977 was 350% and 220 % higher than station 7's average summer TP concentrations for 1979 and 1980, respectively. While the summer average TP concentration at MDC station 2 (downstream of the Longfellow Bridge) for 1977 was 210% and 220% higher than in 1979 and 1980, respectively. Thus, the lower concentrations observed at the Watertown Dam during 1979 and 1980 also could explain why surface TP concentrations were lower at station 2 (Longfellow Bridge) during these years.

In any event, EPA believes it is questionable to use the MDC surface TP data to reach conclusions concerning the affects of the aerators on surface TP levels in the lower Basin. The limited number of TP samples collected each summer and the unknown status of whether the individual data are reflective of dry or wet weather conditions leaves reasonable doubt concerning the representativeness of the data. EPA has learned from its core monitoring program that TP concentrations in the Basin are strongly influenced by rain events, as well as the presence of local sources. It is unknown how the MDC data were influenced by pre-sampling weather conditions or the presence of local sources.

EPA also has observed from the MDC nutrient data that surface TP levels in the Charles River Basin were much higher in the late 1970s than they are today. For example, average summer surface level TP concentrations observed at MDC station 2 during the destratification project (1976 to 1980) ranged between 0.21 and 1.2 mg/l and were approximately 4 to 20 times higher than the 2002 average summer TP levels at EPA station CRBL11 (average 0.05mg/l) which is located in the vicinity of MDC station 2. Consequently, average summer TP concentrations at MDC Station 2 during all years of the destratification project were in such excess that nutrients were not likely to be limiting algal growth. This is in contrast to current summer conditions in the lower Basin where TP concentrations are typically at levels that limit algal growth. In general, when TP concentrations are less than 0.05 mg/l phosphorus is likely to be controlling growth; between 0.06 and 0.08 mg/l phosphorus might be controlling growth; and above 0.1 mg/l, phosphorus is not likely to be limiting algal growth (Wagner, 2004).

Surface Turbulence Effects. The permittee suggests in its December 17, 2003 letter to EPA and MADEP that the operation of the proposed diffuser would result in increased turbulence of the water surface and that this turbulence would likely help retard development of algal masses in the area of the discharge. The permittee bases its theory on an evaluation of Logan Airport wind speed data and lower Basin chlorophyll *a* data and an assumption that the operation of the proposed diffuser would increase surface water turbulence in the vicinity of the facility to a level that would inhibit algal growth. EPA has reviewed this analysis and finds that the permitee has not presented convincing evidence that the operation of the diffuser would increase surface velocities to levels that would reduce algal abundance in the lower Basin. In addition to not providing credible scientific evidence supporting its position, the analysis is based on (1) an unsupported assumption that the operation of the proposed diffuser would increase surface water turbulence to exceed some unspecified level that would retard algal growth; and (2) the highly subjective and unsupported extrapolation of wind speed data from Logan Airport and its variability in the lower Basin. As a result, EPA cannot conclude that algal abundance will be reduced in the lower Basin because of speculations concerning increase surface turbulence from operation of the proposed diffuser.

<u>The Permittee's Approach to Monitoring and Responding to Potential Diffuser Impacts.</u> In its December 17, 2003 letter to EPA and MADEP, the permittee proposed an approach to monitoring and responding to potential diffuser impacts. Under this approach, the permittee proposes that it would be permitted to construct and operate the diffuser, conduct monitoring of the lower Basin, and modify operations of the diffuser if specified thresholds revealed by the monitoring were exceeded. EPA has reviewed this approach and finds that it is unacceptable because it would allow for permittee to significantly degrade and further impair the water quality of the lower Basin. Specifically, the permittee's proposed approach would allow the permittee to cause or contribute to an increase in chlorophyll *a* levels in the lower portion of the Basin to be well above 50 ug/l for extended periods of time before some limited action concerning operation of the diffuser would begin. As discussed above on pages 7 to 9 and 11 to 12, chlorophyll *a* concentrations of this magnitude indicate very poor water and are well above concentrations that are considered necessary to protect designated recreational uses.

<u>Modeling vs. In-situ Monitoring</u>. There are numerous factors associated with the proposed operation of the Kendall Square Station facility (e.g., nutrients, light, temperature, mixing, salinity) that will potentially affect eutrophication in the Basin. Considering the inter-relationships among these factors and the complexities of the physical, biological, and chemical processes involved, EPA recognized that a representative eutrophication water quality model would be necessary to quantitatively evaluate the potential impacts associated with the proposed operation of the facility. At EPA's request, the permittee developed a eutrophication water quality model in September 2001.

EPA had numerous and serious concerns with the permittee's water quality model and its capability to represent algal processes in the Basin. It was during its review of this model that EPA questioned the validity of the approach used by the permittee to simulate the operation of the diffuser (discussed above). Subsequent to receiving this comment, the permittee proposed to abandon its eutrophication modeling effort and replace it with a real-time in-situ chlorophyll *a* monitoring program tied to potential operational constraints at the facility.

EPA's position was that an approach of using chlorophyll *a* monitoring tied to permit conditions must be protective of the Basin's water quality. Furthermore, if EPA and the permittee could not reach agreement on permit conditions that EPA considered to be sufficient to protect the lower Basin from increased algal blooms, then EPA would consider pursuing more stringent thermal load limitations. Without a validated water quality model or protective permit conditions, EPA believes it would be reasonable to limit the permittee to reduced thermal loads (compared to existing permitted conditions) for two reasons. First, as discussed above on pages 16-19, focused research that has examined the relationship between temperature and algal growth, shows clear and convincing evidence that when all other factors affecting algal growth are held constant, higher water temperatures result in higher algal growth rates. Secondly, EPA's water quality monitoring results document high algal levels in the lower Basin during periods when the permittee's thermal load was significantly lower than the allowable thermal load as currently permitted. Under conditions that are favorable for algae growth, an increase in the thermal load from the facility may result in higher water temperatures that could result in more algal biomass in the lower Basin.

<u>Eutrophication Related Monitoring Program</u>. EPA believes that the discharge of the maximum permitted thermal load (556 MMBTU/hr) to the Charles River during the summer months represents a reasonable potential to cause or contribute to eutrophication-related aesthetic and aquatic life impairments in the Basin. However, in light of the summer in-stream temperature limits included in this permit to protect the fish populations of the Charles, it is not clear that the permitted thermal load represents a reasonable potential to cause or contribute to further algal blooms or the proliferation of undesirable "noxious" species. Therefore, eutrophication related monitoring provisions are required in this permit to provide the necessary information for EPA to assess whether the operation of the upgraded facility is causing or contributing to algal blooms in the lower Charles River Basin.

This monitoring is required to assure that the thermal discharge does not cause or contribute to eutrophication-related aesthetic and aquatic life impairments in the Basin. In the event that the final permit does not include in-stream summer temperature limits or if the in-stream or effluent limits are such that a reasonable potential exists for the thermal discharge to cause or contribute to eutrophication related impairments, EPA has developed possible eutrophication-related permit conditions that could be included in the final permit.

The required eutrophication monitoring program consists of seasonal real-time in-situ chlorophyll *a* measurements, weekly nutrient sampling, weekly transmissivity measurements, and biweekly algal analyses. Also, dissolved oxygen and temperature measurements will be conducted at the time that the permittee collects water quality samples.

The in-situ chlorophyll *a* monitoring program requirements will be in effect starting April 1 and ending September 30 of each year. June 1 to September 30 represents the period when algal blooms are most likely to violate Massachusetts Water Quality Standards and impact recreational aquatic life uses. However, monitoring is required between April 1 and May 31 to provide additional information concerning whether blooms are increasing in severity and violating Water Quality Standards as a result of the additional thermal load from operation of the upgraded Kendall facility.

The in-situ chlorophyll *a* monitoring consists of collecting continuous chlorophyll *a* data in two areas of the lower Basin: (1) a reference or background site located between the BU and Harvard Bridges; and (2) the zone or area that is primarily impacted by the permittee's thermal discharge zone. Chlorophyll *a* levels in the two areas will be used to determine whether the facility is contributing to increased algal blooms in the lower Basin. The continuous data will be used to assess the frequency and duration of algal blooms in the lower basin and to determine whether the frequency, duration, and severity of blooms near the facility's discharge has increased relative to the background station.

In addition, the permittee is required to sample the lower Basin for nutrients and for algal analyses and collect transmissivity measurements. Data from the algal analyses will be used to assess whether the thermal load from the facility is causing or contributing to the increased presence of undesirable algae species (i.e., blue greens) in the lower Basin. Nutrient and transmissivity data are necessary for EPA to fully evaluate the chlorophyll *a* data and to determine the roles that nutrients and water clarity have in contributing to algal blooms throughout the summer season. As discussed above, EPA believes nutrients are not limiting algal growth during the late-spring and early-summer season.

<u>Total Maximum Daily Load Study for Eutrophication</u>. Section 303(d) of the Clean Water Act requires that States and authorized Tribes identify water quality impairments and then establish Total Maximum Daily Loads (TMDLs) for all pollutants that are contributing to the impairments. The water quality impairments are identified on the State's Section 303(d) list which is submitted to EPA every two years for approval. TMDLs define the allowable pollutant loading a waterbody can receive while still attaining applicable water quality standards. Also, TMDLs set allocations of allowable pollutant loadings among all contributing sources.

Consistent with Section 303(d) of the CWA and its implementing regulations 40 CFR 130.7, Massachusetts prepared a 303(d) list and submitted it to EPA in 2002, and subsequently, EPA approved this list. The current 303(d) list identifies the Charles River Basin as impaired, and also identifies the pollutants or causes that are contributing to the impairments. In 2002, Massachusetts in cooperation with EPA and the Charles River Watershed Association initiated a TMDL study to address all impairments related to cultural eutrophication in the Basin. The 303(d) listed causes of impairments that will be addressed by this TMDL effort are nutrients, noxious aquatic plants, turbidity, organic enrichment/low DO, and color. The study's objective is to define the allowable amount of nutrients and thermal load that may be introduced to the Basin and allow attainment of designated uses.

A major component of the study is the development of a linked hydro-dynamic water quality model that is capable of simulating the hydro-dynamics of the Basin and the water quality processes related to algal growth and dissolved oxygen in the Basin. Ultimately, the model will be used to evaluate management scenarios and define allowable pollutant load allocations from the contributing sources. The TMDL study will specifically investigate the role increased ambient temperatures (including those resulting from the facility's thermal load) will have on algal levels, species composition, and aesthetic impairments in the Basin.

As with any TMDL, once approved, the TMDL's allocation for pollutant loads, including the allocated load for heat, will be reflected as permit conditions in all relevant NPDES permits for discharges to the water body.

Conclusion. The Massachusetts Surface Water Quality Standards include several provisions applicable to eutrophication, including that surface waters shall be free from pollutants in concentrations that produce undesirable or nuisance species of aquatic life (314 CMR 4.05(3)(5)(a)). Pursuant to Section 301 of the Clean Water Act, an NPDES permit cannot allow a discharge which causes or contributes to non-attainment of State Surface Water Quality Standards.

EPA has reviewed the available information regarding conditions in the Charles River Basin and the permittee's proposals a) for the upgraded facility's increased discharge of heat and b) for up to 50% of the heated effluent to be discharged through a river bottom diffuser. This information includes the permittee's most recent proposals and information submitted to EPA in the permittee's letter of December 17, 2003. Based on this review, EPA sees there is a reasonable potential for the permittee's proposed discharge to contribute to violations of eutrophication-related Surface Water Quality Standards due to the discharge's direct and indirect effects promoting excessive nuisance summer algal growth.

Regarding the thermal load, this reasonable potential is adequately addressed in the draft permit through a combination of the following provisions:

a) the in-stream summer temperature limits establish to protect the balanced indigenous population in the Charles River Basin, contained in Attachment A of the draft permit;

b) the in-stream monitoring requirements, contained in Paragraph 14 of the draft permit; and

c) the potential for permit modifications should the permitted heat load contribute to excessive eutrophication during the term of the permit.

Regarding the proposed diffuser, until the completion of a valid water quality modeling demonstration or other acceptable demonstration that algae blooms will not be worsened with the operation of the diffuser, EPA finds that the operation of the diffuser presents a reasonable potential to cause or contribute to a violation of eutrophication related Surface Water Quality Standards. Also, questions concerning the operation of a diffuser and the fate of toxic contaminants and the effects of higher salinities on fresh water species need to be addressed. Therefore, despite the diffuser's potential habitat benefits, the proposed diffuser is not included in the draft permit and will not be permitted until a more certain understanding of its impacts is available. A model of the Lower Charles River Basin currently being developed to support TMDLs is likely to provide an opportunity to improve our understanding of these impacts.

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